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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Hydraulic Turbo Couplings

We, J. M. VOITH G.M.B.H., a Body Corporate organised and existing under the laws of the Federal Republic of Germany, of Heidenheim/Brenz, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to hydraulic turbo couplings.

In one of the known types of controllable filling hydraulic turbo couplings the working chamber, in which are situated the vaned impeller and runner, or the working circuit which is formed by the impeller and runner, communicates via large orifices with a second rotating chamber, in which is mounted a scoop tube radially adjustable as regards its scoop orifice. The scoop tube in this case acts as an overflow pipe, and the radial position of its scoop orifice determines geometrically exactly the quantity of liquid in the working circuit.

When the scoop tube is withdrawn fully radially inwardly, the working circuit has its maximum filling. In this construction, flow of working liquid through the coupling is generally effected by means of a continuously running pump, and the rate of circulation is substantially dependent exclusively on the size of this pump. This construction is therefore particularly suitable for high loads, that is to say for couplings having a high peripheral speed. In such a case, it is necessary to have a large quantity of working liquid in external circulation in order to dissipate heat from the working liquid.

In contrast to this type of coupling, with the adjustable scoop tube located in a scoop chamber in substantially unrestricted communication with the working circuit, in other constructions of couplings with adjustable scoop tubes, the scoop chamber communicates with the working circuit of the coupling only via relatively restricted orifices, because in these older constructions, the minimum slip, that is to say the difference in speed between impeller and runner, which occurs in continuous operation with full filling, can only be kept as small as is desirable in view of the losses resulting from slip and the resulting heating of the working liquid, by limiting the rate of flow of working liquid out of the working circuit. The quantity of liquid flowing out of the working circuit and picked up by the scoop tube according to its position is in this case, therefore, limited by the internal diameter of the said orifice, in the same way as is substantially also the case in turbo couplings in which the degree of filling is controlled by regulation of the speed of a filling pump or by valves in the filling duct.

In turbo couplings of the first type described above a filling pump for example pumps the working fluid, usually oil, from a sump into the working circuit of the coupling. The oil passes from the working circuit to the scoop chamber, where it is picked up by the scoop tube at a geometrically exactly adjustable rate determined by the scoop tube setting, and is re-supplied to the sump, in some cases after passing through a cooler.

The quantities of liquid which can be circulated in this type of coupling in a circuit external to the working circuit are——as mentioned—dependent substantially exclusively on the capacity of the filling pump, so that in the case of very highly loaded couplings up to say four times the particular filling of the working circuit can be pumped per minute through the latter and correspondingly large amounts of heat can be dissipated. Due to this high heat dissipation certain difficulties arise in this construction of coupling due to foaming in the sump, causing for instance occasional failure of the filling pump, so that fluctuations occur in the power transmission capacity of the coupling. In addition, in this event the quantity of liquid circulating is temporarily reduced with the reduced pumping capacity of the filling pump and hence the heat dissipation is impaired. Another known disadvantage of foaming is the reduction in the life of the working liquid.

With a view to overcoming these and other

disadvantages of known turbo couplings there is provided according to this invention an improved hydraulic turbo coupling having a working circuit constituted by a vaned impeller and a vaned runner, and having a liquid chamber in substantially unrestricted communication with, and of substantially the same diameter as, the said working circuit and rotatable with the impeller or runner, the said turbo coupling also being provided with a scoop tube or overflow device which is adjustable to vary the distance of its scoop or equivalent opening radially inward from the circumference of the said liquid chamber and is adapted, under the action of hydrodynamically produced liquid pressure, to remove liquid from the said liquid chamber or from the working circuit, and being provided additionally with a filling device which is arranged to discharge liquid through a delivery pipe into the working circuit of the turbo coupling, wherein the scoop tube or overflow device and the delivery pipe are in communication with a common filling duct which is arranged to discharge into the working circuit.

In this improved hydraulic turbo coupling at least the major part of the working liquid picked up by the scoop tube is transferred directly to the delivery pipe. Whilst retaining the excellent properties of the said known type of controllable turbo couplings, viz.

(a) very high loading capacity, due to the possibility of removing practically unlimitedly high quantities of heat,

(b) exact accuracy of control due to the fact that the degree of filling corresponds geometrically exactly to the particular setting of the adjustable scoop tube, and

(c) least possible diameter of the rotating coupling parts, since there is no additional rotating oil reservoir chamber which would increase the coupling diameter,

it is possible by using a construction according to the invention to return the large quantities of externally circulating liquid always free from foam to the working circuit of the coupling in a closed cycle.

In couplings with controllable degree of filling, in which the scoop tube projects into a reservoir chamber rotating with the impeller or runner and projecting over and enclosing the working chamber of the coupling, into which reservoir chamber the coupling continuously delivers some working liquid during operation through restricted orifices, and also in couplings with a stationary scoop tube, in which the degree of filling is controlled by a motor controlled pump, it is known *per se* to return the working liquid picked up by the scoop tube to the working chamber of the coupling in a closed duct. In both cases, however, these are couplings in which the degree of filling with constant slight removal of liquid from the working circuit is controlled by a regulated temporarily increased supply of working liquid, in which therefore during the normal steady working condition only a very small quantity of liquid is in external circulation, being maintained in circulation exclusively by the scoop tube.

Also, in modification of the abovementioned controllable turbo coupling in which, for the geometrically exact adjustment of the degree of filling the principle of the arrangement of a scoop tube in a scoop chamber in unrestricted communication with the working circuit and situated axially adjacent the working circuit was retained, but for less exacting operation conditions the flow of working liquid i.e., the external circulation during normal steady operation, was relinquished, it is known *per se* to connect the delivery end of the scoop tube directly to the filling duct, which for this purpose must be under a constant pressure corresponding substantially to the scoop tube pressure. In this construction, however, liquid is removed from or is introduced into the coupling only during a setting operation, that is to say, after inward or outward movement of the scoop tube orifice, while in steady operation, no circulation takes place at all. This construction, therefore, is only suitable for couplings subjected to low loads, in which during steady operation removal of heat through the walls of the coupling is adequate, and in which the problem solved by the invention does not occur.

In contrast thereto, the present invention provides a coupling in which a large and constantly uniformly large quantity of liquid is supplied to the working circuit of the coupling, and a large quantity of liquid is constantly, that is to say even during steady operation, removed by the scoop tube, and in which the change of degree of filling is effected by temporary, and controlled further increased removal or somewhat reduced removal of liquid from the working circuit. Unlike all known coupling constructions, the question here is of obtaining foam-free, i.e. trouble-free operation in a coupling with high external circulation, and despite this high circulation, in order in this way to obviate unwanted fluctuations in the power transmission capability and more particularly also unwanted fluctuations in heat dissipation, and thus overheating of the coupling or of the working liquid.

In a coupling according to the invention, in steady operation, that is to say, therefore, as long as there is just no change to a larger or smaller degree of filling, the external circulation is no longer maintained, as is the case with this type of coupling without the feature of the invention, by the filling device, for instance by the constantly running filling pump, but by the action of the scoop tube, utilising the dynamic pressure of the liquid flowing towards the scoop orifice. In this case, therefore, in manner known *per se*, the velocity of the flowing liquid is used for maintaining the

circulation which would otherwise be lost. Since in the known constructions, however, the external circulation corresponds only to the small quantities which emerge continuously through the said restricted orifices from the working circuit, in a construction according to the invention, however, large quantities of energy are saved, corresponding in a construction according to the invention to the large pumping capacity of the filling pump or of the scoop tube itself.

In addition, during steady operation the sump is completely relieved from the circulation and a longer life is also obtained for the working liquid. Due to the sump being relieved of the liquid circulation, the casing forming the sump heats up only to a slight extent, so that due to the lower thermal expansion of the casing material, there is also only slight alteration in the height of the casing and hence a better alignment is ensured between the coupling unit and the engine with which it is to be coupled. In addition, for purposes of bearing lubrication, sufficiently cool liquid can be taken from the sump by a special lubricating pump, and thus a special cooler for the lubricating liquid, which must be kept at a substantially lower temperature than the working liquid, becomes unnecessary.

In a coupling according to the invention, the filling pump serves to maintain continuously a certain superimposed pressure, which in the case of adjusting movements of the scoop tube for greater degree of filling, serves to fill the coupling corresponding to the new geometrical position of the scoop orifice and serves also to replace any leakage losses. In the case of a reduction in filling or a complete emptying of the coupling resulting from a correspondingly large outward movement of the scoop tube, the excess working liquid is discharged to the sump through the filling pump, the high pressure of the latter being overcome. Conversely, with an increase in filling, there is the advantage that, upon the displacement effected for this purpose of the scoop orifice to a smaller radius, re-filling is also effected by return of working liquid through the scoop tube, thus accelerating the filling operation. The scoop tube and the duct connected to the scoop tube will thus temporarily have liquid flowing through them in the reverse direction; filling will therefore occur through the filling duct *and* through the emptying duct.

The filling pump is advantageously a centrifugal pump, and in the pump delivery duct, before entry into the working chamber of the coupling, there is provided in known manner a throttle valve, which is adjustable by the operator or, for the purpose of maintaining a definite temperature of the working liquid, can be arranged to be automatically controlled within certain limits by a thermostat. In some cases it is advantageous for the filling pump to be a two-stage centrifugal pump, and for the scoop tube duct to be connected between the two stages.

According to a further feature of the invention, not all of the liquid picked up by the scoop tube is introduced into the filling pump delivery duct, but only a part thereof, the remainder being passed directly as heretofore to the sump, in order in this way to utilise the cooling effect of the otherwise still liquid in the sump.

Instead of using a centrifugal pump as filling pump, it is also possible to use a gear pump having an overflow valve for adjustment of the pressure. It is also possible to use, instead of a pump, an elevated tank as filling device, if, say a small auxiliary pump is provided for pumping any leakage liquid from the sump to the elevated tank.

As already mentioned, in a coupling according to the invention, if the degree of filling has to be increased, the filling operation is accelerated due to liquid being supplied not only on the inlet side, that is to say, through the filling device, but also through the scoop tube itself, liquid flowing through the latter in the reverse direction. In order also to accelerate the emptying operation, the arrangement may be such that, due to the temporary increase in pressure produced in the initial stage of the emptying operation, a throttle valve built into the filling duct is at first closed, thus shutting off further supply to the coupling and at the same time a direct discharge path to the sump is opened. On completion of the emptying operation, as soon as the scoop tube pressure has returned to normal, the throttle valve returns to its normal position and the direct discharge path to the sump is closed again.

The invention will now be described in more detail with reference to the accompanying drawings, in which:—

Fig. 1 shows in sectional elevation a coupling with a pivotal scoop tube and a filling pump drawing from a sump, and a control valve coupled to the scoop tube and included in the filling duct leading to the coupling.

Fig. 2 is a sectional view of the control valve, which is constructed so that part of the liquid picked up by the scoop tube always passes into the sump, and

Fig. 3 shows diagrammatically an embodiment of the invention in which a gear pump serves as the filling pump.

Referring to Figs. 1 and 2, an engine, not shown, drive the impeller 4 of the hydraulic turbo coupling at a high speed via the engine shaft 1 and the gear wheels 2 and 3. The runner 5 is carried by the output shaft 6. It is enclosed by a casing 7 connected to the impeller and so constructed that between the back of the runner and the casing 7 a scoop chamber 8 is provided for a scoop tube 9, the scoop chamber being in substantially unrestricted communication with the working

circuit enclosed by the vaned impeller and runner. The scoop tube 9 is pivotally mounted on a spindle 12 in a manifold 11 rigidly connected to the housing 10 of the coupling. The scoop tube 9 is connected at its inner end to a space 13 formed in the manifold 11 and in turn connected by a pipe 14 to a cooler 15 in such a manner that the working liquid picked up by the scoop tube passes through the cooler 15. From the cooler 15, the pipe 16 leads to a throttle valve housing 17, which is also connected by a pipe 18 to a stationary filling space 19 in the manifold 11. Also leading to the valve housing 17 is pressure or delivery pipe 20 of a centrifugal pump 21 drawing from a sump 22. A control valve 23 slidably mounted in the valve housing 17 is provided with suitable control surfaces and orifices, and is controlled by a cam 24 coupled to the spindle 12 of the scoop tube 9.

The valve 23 is shown in the position which it assumes when the scoop tube 9 is in the position for complete filling, that is to say, with the scoop orifice in the radially innermost position. In this position, the valve 23 allows the working liquid flowing through the ducts 14 and 16 to return substantially unthrottled to the filling duct 18 and the filling space 19. In addition, the filling pump delivery pipe 20 is in communication with the filling duct 18.

When the scoop tube 9 is swung for example from the "coupling empty" position to the "coupling full" position, that is to say it is retracted into its radially innermost position, the pressure on the scoop orifice of the scoop tube diminishes considerably, and the liquid pumped by the filling pump 21 can pass by way of the delivery pipe 20 and the valve 17/23 on the one hand through the filling pipe 18 and on the other hand backward through the pipe 16, cooler 15 and pipe 14, through the scoop tube 9 into the scoop chamber 8 and thence into the working circuit. As soon as the coupling has filled to the degree determined by the scoop tube setting, back-pressure builds up again in the pipes 14 and 16, so that the pump pressure is overcome, and liquid flows through the pipes 14 and 16 in the normal direction again, that is to say, the external oil circulation is substantially established again through the pipes 14 and 16. The pump 21 then has only to replace the leakage losses and to maintain the superimposed pressure.

The coupling known *per se* of the valve 23 with the scoop tube adjusting spindle 12 by means of the cam 24 ensures that the external circulation is greater, the greater is the production of heat in the turbo coupling.

Referring to Fig. 2, the valve 33 is so constructed that a partial flow of the liquid picked up by the scoop tube 9 and supplied to the valve housing 17*a* by way of the cooler and through the pipe 16 can always pass through the ports 25 into a pipe 26 leading to the sump tank 22. In addition, in this case, the connection between the valve body and the cam 24 coupled to the scoop tube adjusting spindle 12 is not a unidirectionally operating connection, but a positive connection, in that a resiliently yielding connection is established by the interposition of a spring 27. This affords the possibility of accelerating the operation of emptying couplings, since on sudden outward pivotal movement of the scoop tube the resulting pressure increase in the scoop tube ducts 14/16 forces the piston-shaped valve 33 momentarily upwardly against the force of the spring 27 and thereby momentarily interrupts the connection between the filling duct 18 at the edge 28, so that for rapid partial or complete emptying the liquid picked up by the scoop tube 9 cannot return directly to the coupling but passes through the pump delivery pipe 20 against the pump pressure into the sump tank 22.

In the embodiment of the invention shown in Fig. 3, the centrifugal pump of the embodiment shown in Fig. 1 is replaced by a gear pump 31. In addition, in this case, the cooler 15 follows the point of connection of the scoop tube ducts 14*a*, 16*a* to the pump delivery pipe 20*a* in the direction of the normal external circulation. The scoop tube and indeed the turbo coupling are not shown. An adjustable pressure relief valve 29 is connected to the scoop tube duct 14*a*. A throttle valve 17*b* adjustable by the operator or automatically is in this case also incorporated in the filling duct 18*a*. For the automatic control of this valve there may be used for example a thermostat which controls the rate of circulation of working liquid as a function of the temperature of the liquid or of the heat produced at any other suitable point, so that for example the temperature of the working liquid is kept within predetermined limits.

WHAT WE CLAIM IS:—

1. Hydraulic turbo coupling having a working circuit constituted by a vaned impeller and a vaned runner, and having a liquid chamber in substantially unrestricted communication with, and of substantially the same diameter as, the said working circuit and rotatable with the impeller or runner, the said turbo coupling also being provided with a scoop tube or overflow device which is adjustable to vary the distance of its scoop or equivalent opening radially inward from the circumference of the said liquid chamber and is adapted, under the action of hydrodynamically produced liquid pressure, to remove liquid from the said liquid chamber or from the working circuit, and being provided additionally with a filling device which is arranged to discharge liquid through a delivery pipe into the working circuit of the turbo coupling, wherein the scoop tube or overflow device and the delivery pipe are in communication with

a common filling duct which is arranged to discharge into the working circuit.

2. Hydraulic turbo coupling according to claim 1, wherein a connecting duct providing communication between the scoop tube or overflow device and the common filling duct is provided with a branch pipe, dimensioned to permit partial flow and opening into a sump from which liquid is taken by the filling device.

3. Hydraulic turbo coupling according to claim 1 or 2, wherein the filling device comprises a filling pump constructed as a centrifugal pump, and an adjustable throttle valve is provided between the filling pump and the working circuit of the coupling.

4. Hydraulic turbo coupling according to claim 1 or 2, wherein the filling device comprises a filling pump constructed as a gear pump which has an adjustable pressure relief valve.

5. Hydraulic turbo coupling according to any one of claims 1 to 4, wherein the scoop tube or overflow device is of such a form that liquid can also flow through it in the reverse direction i.e. from the filling device.

6. Hydraulic turbo coupling according to claim 3, wherein means are provided which, in the event of a predetermined pressure being exceeded in a connecting duct through the the scoop tube communicates with the common filling duct, open an additional orifice for the discharge of liquid into a sump from which liquid is taken by the filling device, and which at the same time close the throttle valve.

7. Hydraulic turbo coupling according to claim 6, wherein the adjustable throttle valve is a piston valve located in a position beyond that at which the connecting duct communicates with the delivery pipe, the said piston valve being arranged to respond to the increase in pressure in the connecting duct at the start of an emptying operation in such manner that the delivery pipe is momentarily closed off and an auxiliary orifice or an additional auxiliary orifice leading back into a sump is opened.

8. Hydraulic turbo coupling according to any of claims 1 to 7, wherein a sump from which liquid is taken by the filling device also serves as a lubricating oil reservoir from which a lubricating oil pump draws directly.

9. Hydraulic turbo coupling substantially as hereinbefore described with reference to Fig. 1, with if desired the modification of Fig. 2, or with reference to Fig. 3 of the accompanying drawings.

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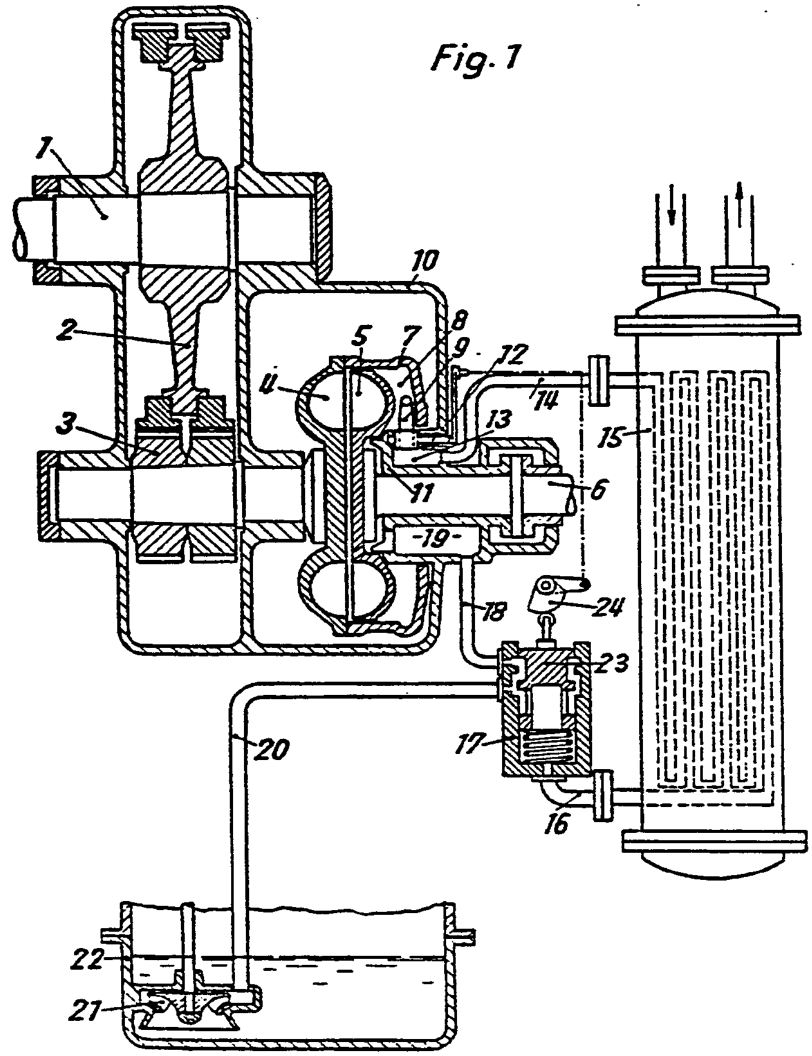
Fig. 1



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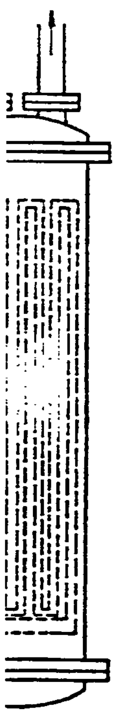

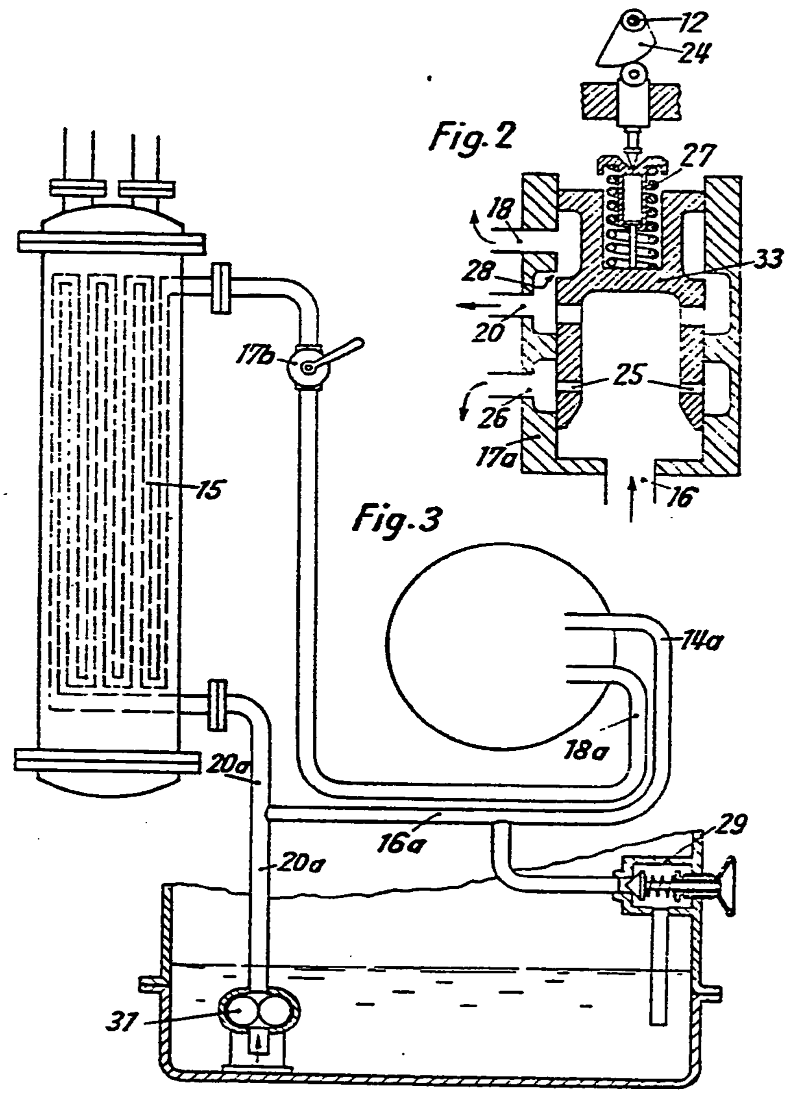

Fig. 2

Fig. 3

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Sheets 1 & 2

Fig. 1

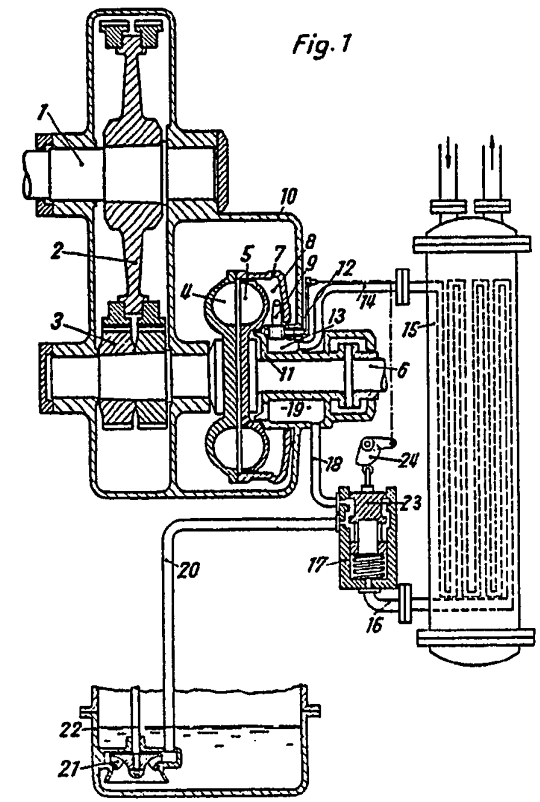
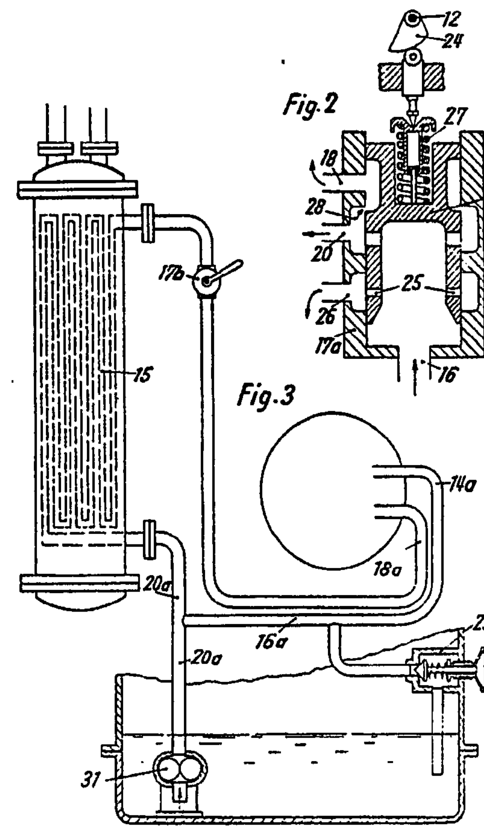


Fig.2

Fig.3



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